

Development of a Multi-Ion Focused Ion Beam System

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We are in the final year of developing an integrated system that combines a Multi-Ion Focused Ion Beam (MIFIB) and Scanning Electron Microscope (SEM) into an analysis chamber with a 5-axis sample manipulator. When completed the system will allow for ion sculpting and direct, maskless, ion implantation using a variety of ion species, all with nanometer precision and resolution. The motivation for this project arose from nanofabrication studies where it became clear that ions other than Ga were needed either to avoid unwanted contamination, or for specific doping applications.

This new instrument employs a mini-RF driven plasma source to generate focused ion beam with various ion species, a FEI two-lens electron (2LE) column for SEM imaging, and a five-axis manipulator system developed by Zyvex.

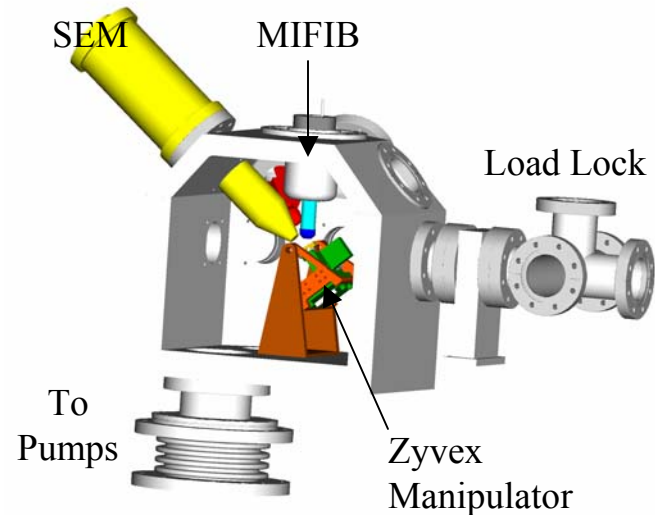


Figure 1. A Multi-Ion Focused Ion Beam (MIFIB) system integrated into an analysis chamber with a Scanning Electron Microscope (SEM) and 5-axis sample manipulator.

- The mini-RF plasma source consists of a 1.5 cm inner diameter ceramic chamber and two-layers of copper wires as an external antenna. Ion beams are extracted through a 50- μm -diameter extraction aperture. Ar^+ ion current density as high as 100 mA/cm^2 has been obtained with only 150 W of input RF power. An all-electrostatic two-lens column has been designed to focus the ion beam extracted from the source. Based on the ion optics simulation, beam spot size as small as 100 nm can be achieved at beam energy between 5 to 35 keV if a 5- μm -diameter extraction aperture is used. Smaller beams are possible with smaller apertures. The FEI 2LE column, which utilizes Schottky emission, electrostatic focusing optics, and stacked-disk column construction, can provide high-resolution (as small as 20 nm) imaging capability, with fairly long working distance (25 mm) at 25 keV beam voltage. Such an integrated MIFIB/SEM dual-beam system will not only improve the accuracy and reproducibility when performing ion beam sculpting and direct implantation processes, but will also enable researchers to perform cross-sectioning, imaging, and analysis with the same tool.

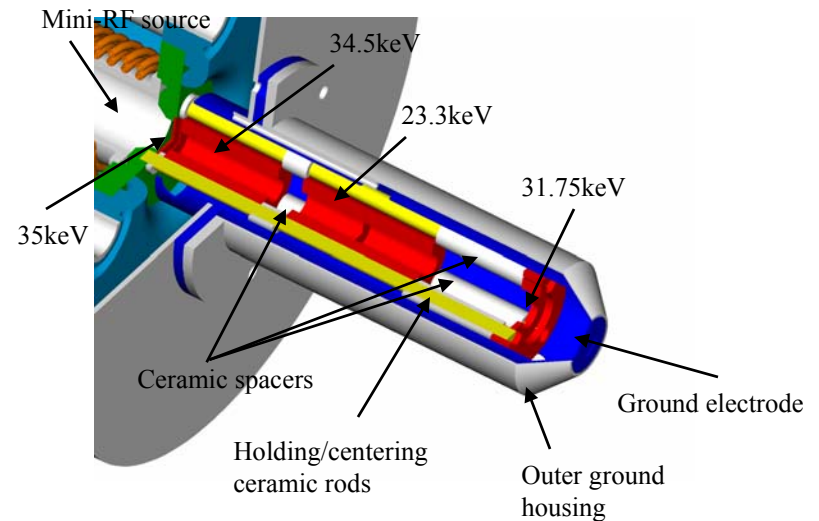


Figure 2. An all-electrostatic two-lens system is used to focus the ion beam extracted from the ion source.